POST OFFICE

Third Report of the Mobile Radio Committee

LONDON
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1959
PRICE 1*s.* 3*d.* NET

Mobile Radio Committee
Third Report

Postmaster General,

1. By taking advantage of improvements in equipment design, the standard channel spacing for V.H.F. mobile radio services can be narrowed to make more channels available for the development of those services. This principle is generally accepted by users and manufacturers. In accordance with the recommendations in our Second Report, the change-over from 100 kc/s to 50 kc/s channel spacing in the 165–173 Mc/s band (the land-mobile "high band") is already in progress and is due to be completed by January, 1962. Furthermore, following the agreement reached between countries at the Hague Conference in January, 1957, maritime mobile services in the international maritime V.H.F. band are likewise developing on the basis of 50 kc/s channelling. The channel spacing for land-mobile services in the "low band" (around 80 Mc/s) has been 50 kc/s since the band came into general use about ten years ago.

2. To cater for the continuing growth of the land-mobile services, 25 kc/s channelling has for some time been regarded as the logical next step, and in our Second Report we recommended (para. 7 (2)) that the possibility of introducing it in both the low and high bands should be examined. To this end, a provisional specification for suitable equipment was prepared by the Post Office in collaboration with manufacturers, and field trials were carried out when equipment meeting the specification became available.

3. The trials were first made in the low band and the results were satisfactory. Having considered a technical report by the Post Office Engineering Department, together with a covering note by a group of our members whom we nominated to supervise the trials, we fully agreed that 25 kc/s channelling in the low band could be recommended with confidence. The two reports are reproduced at *Annex I*. The corresponding trials in the high band are still in progress.

4. In the meantime there is a pressing need for additional channels in the low band. We have, therefore, concentrated on the arrangements for introducing 25 kc/s channelling in that band. We appointed a Sub-Committee to draw up a plan for the sub-allocation of the channels on a 25 kc/s basis. The Sub-Committee's report is at *Annex II;* it has been seen by the organizations representing users and manufacturers, who are generally in agreement with the proposed distribution of channels and the time-table for implementation of the plan. We accordingly recommend these proposals, which are summarized in para. 16 of *Annex II*, it being understood that the additional channels specified for each category of user would be allotted only on the basis of proved need.

W. A. WOLVERSON (*Chairman*).

J. R. BRINKLEY.	J. W. CLATER.
H. A. DANIELS.	H. D. EDWARDS.
G. W. HARVEY.	I. T. LAWMAN.
L. P. S. ORR.	G. F. PEIRSON.
F. JERVIS SMITH.	R. L. SMITH-ROSE.
C. W. SOWTON.	F. J. WYLIE.

G. McIVOR
A. A. MEAD } *Joint Secretaries.*

9th March, 1959.

List of Annexes

Annex 1

25 kc/s channelling

The Chairman,

Mobile Radio Committee.

1. At the 26th meeting of the Mobile Radio Committee we were given responsibility for reporting to the Committee the outcome of the trials of 25 kc/s channelling in the low band.

2. A report on the trials by the Post Office Engineering Department is attached.

3. The following conclusions can he drawn from this Report:

(i) The various interference tests have shown that mobile services could be operated on the basis of 25 kc/s channelling in the low band with a satisfactorily low degree of mutual interference.

(ii) The tests also demonstrated that AM and FM systems were not significantly different in performance.

(iii) The tests of compatibility have shown that 25 kc/s systems could be operated alongside existing 50 kc/s systems on interleaved channels (produced by the method explained in pages 26 and 27 of the Second Report of the Mobile Radio Committee), though adjacent-channel interference might cause some difficulty where several services are working on adjoining channels in the same area. The interference would affect the 50 kc/s systems more than the 25 kc/s systems but would probably cause less inconvenience than normal channel-sharing.

(iv) The tests have shown that equipment of commercial standard operates satisfactorily to a performance specification designed to allow of 25 kc/s channelling.

4. The overall performance of the 25 kc/s equipment working under 25 kc/s channelling conditions was better than would be obtained from equipment conforming to the current 50 kc/s specification and working in 50 kc/s channels. The frequency accuracy and stability of the 25 kc/s transmitters are particularly impressive.

5. So far as the low band is concerned, we are satisfied that sufficient information has now been obtained to justify a firm recommendation in favour of 25 kc/s channelling.

(Signed) H. A. DANIELS.
J. R. BRINKLEY.
J. W. CLATER.
L. P. S. ORR.
C. W. SOWTON.
A. A. MEAD (*Secretary*).

17th April, 1958.

Mobile Radio Committee

Trials of Private V.H.F.-Mobile Radio Equipment using 25 kc/s Carrier Spacing in the 71·5-88·0 Mc/s Band

1. Introduction

For a number of years the 71·5–88·0 Mc/s land-mobile band has used channels with 50 kc/s carrier spacings. Recently, however, congestion of the channels has made it necessary to consider reducing the spacing to 25 kc/s and the report describes tests carried out from the 12th June to 29th November, 1957 with this objective in mind.

Provisional specifications for 25 kc/s spacing private V.H.F. mobile equipment had already been prepared by the G.P.O. in consultation with manufacturers and other interested parties. The equipment to be used, which was all provided by one manufacturer, was first tested against the specifications, after which the trials themselves were carried out. The program was agreed between the equipment manufacturer and the G.P.O. and was also made known to other manufacturers.

To complete the picture tests were made of compatibility as between the equipment satisfying the provisional 25 kc/s specifications and equipment satisfying current 50 kc/s specifications.

2. General

For tests of the AM and FM equipments considered separately three base-station sets were installed at Arnold Telephone Exchange, and three mobile-station sets were fitted in a single van. Frequencies of 85·025, 85·05 and 85·075 Mc/s were used for the base-station transmitters, while the mobile-station transmitters worked on 71·525, 71·55 and 71·575 Mc/s, the base- and mobile-station frequencies being paired in the order shown and referred to as Channels 1, 2 and 3 respectively. Three transmitting aerials, together with a common receiving aerial, were provided at the base station, but only one aerial was fitted on the van and was switched from set to set as required. The aerials at Arnold Telephone Exchange were about 70 feet above ground and the site has no significant advantage in height over the surrounding terrain. The conditions of test were representative of stations in an urban area.

The base- and mobile-station transmitter powers (ERP) were respectively 10 watts and 3 watts on AM and 20 watts and 5 watts on FM.

The arrangement of the equipment was varied during the trials to test:

(*a*) thc 25 kc/s AM system (12th June to 21st August);

(*b*) the compatibility of the existing-type 50 kc/s AM system with the 25 kc/s AM system;

(*c*) the 25 kc/s FM system (15th October to 19th November);

(*d*) the compatibility of the 25 kc/s FM system with the 25 kc/s AM system.

Tests for compatibility of the 25 kc/s AM and FM systems with 50 kc/s FM systems were not considered necessary as there are few of the latter in use.

All the 25 kc/s and 50 kc/s equipment, used during the tests, were supplied by one manufacturer and complied respectively with the minimum standards of the provisional specifications for 25 kc/s equipment and the current specifications for 50 kc/s equipment.

Daily measurements were made of the frequencies of the transmitters, and frequent tests were made of adjacent-channel interference, desensitization, cross-modulation and inter-modulation. No maintenance adjustments were made except as necessitated hy the faults mentioned later.

For five days per week throughout the tests, the hase-station transmitters were arranged to radiate plain carrier automatically for one minute in every three when they were not otherwise heing used for tests. The mobile sets were left in the stand-by condition when not in use.

3. Interference between Channels in same Area

Interference hetween channels arises from one or more of the following causes:

(*a*) Adjacent-channel interference;
(*b*) Desensitization of the receiver (Blocking);
(*c*) Cross-modulation;
(*d*) Intermodulation.

Experience has shown that such interference is generally greater for reception at a mobile station than at a base station. Consideration here is therefore restricted to interference at the mohile stations.

The conditions under which the different forms of interference (*a*), (*b*), (*c*) and (*d*) are most noticeahle are summarised in Table 1 helow and in subsequent paragraphs, and are those adopted for the tests.

TABLE 1

SUMMARY OF CONDITIONS FOR THE VARIOUS TYPES OF INTERCHANNEL INTERFERENCE

Type of Interference	Conditions for Interference		Sources of Interference
	Wanted Carrier	Unwanted Carrier(s)	
Adjacent channel	Nil for AM receiver (Note 1) Unmodulated for FM receiver (Note 2)	Modulated ...	Unwanted signals in either of the immediately-adjacent channels
Desensitization...	Modulated	Modulated or Unmodulated	Unwanted signals in nearby channels
Cross-modulation	Modulated or Unmodulated	Modulated ...	Unwanted signals in nearby channels
Intermodulation	Nil for AM and FM (Note 1)	Two; one, at least, modulated	Unwanted signals in appropriate combinations of two or more channels

Note 1.—The absence of a wanted signal is the worst case and was taken for the purposes of the trials.

Note 2.—A weak unmodulated wanted signal is the worst case and was taken for the purposes of the trials.

Adjacent-channel interference is the interference in a channel resulting from modulated transmissions in either of the two adjacent channels. For tests of this type of interference on the AM system the two outer channels (Channels 1 and 3) in turn were amplitude-modulated and, in the ahsence of a wanted carrier

listening tests were made on the mobile-station receiver tuned to the centre channel (Channel 2); the mobile station being moved from the base station until the adjacent-channel interference could only just be heard. Further tests were carried out substituting FM for AM on the adjacent channels.

Turning now to the FM tests, the FM receivers are fitted with a " squelch " control which cuts off the audio output when the noise level from the discriminator (above the speech band) exceeds a predetermined level. When a carrier in the desired channel is received this noise is reduced and the " squelch " action ceases. Whereas in the preceding AM tests it was possible to assess adjacent-channel interference with no carrier in the wanted channel, in the FM-system tests a small-level carrier is necessary to inhibit the " squelch " action. This is because interference which of itself is insufficient to inhibit the " squelch " action may still be sufficient to degrade reception when the " squelch " is inhibited by a weak wanted signal. Thus the FM tests of adjacent-channel interference were made with a wanted-carrier level which when modulated would produce a 10 db signal-to-noise ratio at the output of the mobile-station receiver tuned to Channel 2. The distance of the mobile station from the base station at which the observed signal-to-noise ratio was reduced to 7 db when an adjacent channel was modulated was taken as the criterion.

Desensitization (*Blocking*) may arise from the presence of one or more strong unwanted carriers, modulated or unmodulated, in nearby channels. It differs in character from adjacent-channel interference because it reduces the sensitivity and does not necessarily cause audible interference.

On the AM system the method of test chosen was, in the absence of a wanted carrier, to note the reduction of noise in the mobile-station receiver on Channel 2 by transmissions in Channels 1 or 3. This directly indicates the reduction of sensitivity.

On FM systems using " squelch " control in the manner already described, the desensitization might be sufficient to affect removal of the " squelch " suppression by the wanted signal. For the FM tests of desensitization, therefore the " squelch " suppression was removed by a wanted carrier just sufficient, when modulated, to give a 10 db signal/noise ratio; and the point at which the " squelch " suppression was then reintroduced by blocking from an adjacent channel was taken as the criterion.

Desensitization of a receiver is generally due to insufficient RF selectivity; strong unwanted signals can cause the RF gain to fall by overloading which cannot be corrected by any AGC circuits operated after the IF circuits.

Adjacent-channel interference, defined earlier, generally occurs before desensitization from signals in the same interfering channel.

Cross-modulation can occur in a receiver when a strong, modulated, unwanted signal is received in the presence of a weaker wanted signal, either modulated or unmodulated. The unwanted signal need not necessarily be in an adjacent channel.

Tests for this type of interference were made by using a comparatively weak unmodulated carrier in Channel 2 and observing the cross-modulation from strong, modulated carriers in Channels 1 or 3. On the AM system a signal-to-cross-modulation ratio* of 20 db was taken as the minimum tolerable.

To simulate the test conditions laid down in the provisional specifications the wanted carrier was arranged to be 30 db weaker than the unwanted carrier at the receiver input. To obtain these conditions the wanted signal was artificially

* The ratio of the power output of the receiver from the wanted signal, when modulated, to the power output due to the cross-modulation alone.

attenuated to the required degree at the base station, and the mobile station was brought closer and closer to the base station until the signal-to-cross-modulation ratio fell to 20 db. The distance from the base station was noted.

On the FM system the degree of cross-modulation was very much less than on the AM system. On FM a signal-to-cross-modulation ratio as low as 20 db could not be obtained without approaching so close to the base station that desensitization was the limiting factor.

Cross-modulation on AM and FM systems is a complex subject and by and large it is due to insufficient selectivity and is also dependent on the distribution of gain and selectivity within the receiver.

Intermodulation products are generated at a transmitting station when two or more of its transmitters are operated simultaneously. They are also generated in receivers when two or more signals are impressed on the input.

This report deals only with intermodulation in receivers, because, with reasonable care, intermodulation at base transmitting stations can be made considerably less than that in the mobile-station receivers. This condition obtained during the trials, but only after re-arrangement of the transmitting aerials.

Third-order products are generally the most troublesome, and the test arrangements ensured that a third-order product of two of the channels taken together fell in the remaining channel. One or more of the unwanted signals was modulated to give an audio-frequency output.

The criterion used for this interference was the distance at which the intermodulation product could just be heard in the absence of a wanted signal.

Intermodulation products arise mainly from insufficient RF selectivity in the receiver, and from non-linearity before the IF selectivity becomes effective.

Tests for intermodulation interference were made in turn on Channels 1 and 3 in the absence of a wanted signal. In the first case Channel 2 was modulated, but the carrier on Channel 3 was unmodulated; in the second, Channel 2 was modulated and Channel 1 was unmodulated. The distance from the mobile station to the base station was increased until: (*a*) on the AM system intermodulation interference was just audible, and (*b*) on the FM system interference caused the " squelch " suppression to be removed.

4. Trials of 25 kc/s AM System

(a) *Frequency accuracy and stability*

The frequencies of all AM, 25 kc/s-spacing, transmitters were measured daily for about ten weeks and the maximum departures from the nominal frequencies were as follows:—

three base-station transmitters	...	...	$-0{\cdot}8$ to $+0{\cdot}6$ kc/s
three mobile-station transmitters	...	...	0 to $-0{\cdot}9$ kc/s

The provisional specifications permit a variation of $\pm 1{\cdot}5$ kc/s and $\pm 3{\cdot}0$ kc/s for the base- and mobile-station transmitters respectively, to cover specified supply-voltage and temperature variations which, however, were not reached during the trials. Initial bench tests indicated that the permissible frequency variations are not likely to be exceeded.

The frequency stability of the oscillators in the receivers is not specified directly; it is covered implicitly by measurements of interference from adjacent-channel transmissions on their nominal carrier-frequencies plus or minus the departures permitted in the specification. In testing mobile-station receivers as a separate operation the adjacent-channel carrier-frequencies used would be arranged to differ from nominal by $\pm 1{\cdot}5$ kc/s, i.e. the permissible variation of the base-station transmitters. Similarly for base-station receivers the

adjacent-channel carrier-frequencies would be arranged to differ from nominal by ± 3·0 kc/s, i.e. the permissible variation of the mobile-station transmitters. The interference from an adjacent-channel transmission should then not exceed the specification limits when the receiver is subject to the permissible variations of temperature and supply voltage. However, separate tests of receiver frequency stability have not been made because the adjacent-channel-interference tests reported immediately below implicitly cover the effect of receiver drift.

(b) *Adjacent-channel interference*

In the absence of a wanted signal, speech from adjacent channels was just detectable on the mobile-station receivers when within about 200 yards of the base station. This test was repeated weekly with substantially the same result.

(c) *Desensitization interference (blocking)*

Desensitization interference occurred on the mobile station receivers when within about 100 yards of the base station.

(d) *Cross-modulation interference*

A 20 db signal-to-cross-modulation ratio was obtained on the mobile-station receivers from a transmission on an adjacent channel, at a distance of about 400 yards from the base station. At this point the ratio of the unwanted signal to the wanted signal was + 30 db at the receiver input.

(e) *Intermodulation interference*

Interference due to intermodulation products generated in the mobile-station receivers occurred up to distances of about 500 yards.

(f) *Equipment faults*

During the trial period of ten weeks, eight faults occurred on the mobile-station receivers and four on the base-station transmitters. Five of the former were on one particular receiver, but all were of a general nature and could not be attributed to 25 kc/s channelling.

5. Compatibility as between 50 kc/s and 25 kc/s Systems on Adjacent Channels

The tests for compatibility on AM systems described below were limited in duration and confined to a check of the frequency accuracy of the 50 kc/s transmitters and an assessment of adjacent-channel interference. The comparative lack of selectivity of the 50 kc/s receivers caused any cross-modulation and intermodulation effects on the three channels used for the trials to be obscured by adjacent-channel interference. Because of this lack of selectivity, tests were made with AM equipment only; the results with FM or a combination of FM and AM would not have been materially different.

(a) *Frequency accuracy and stability of 50 kc/s equipment*

The maximum variations from the nominal frequencies were as follows:—

one base-station transmitter	...	...	− 0·9 to + ·05 kc/s
one mobile-station transmitter	...	...	+ 2·5 to + 5·0 kc/s

The current specification for 50 kc/s equipment permits a variation of ± ·01 per cent. on the nominal carrier-frequency, i.e. approximately 8·5 kc/s for the base station and 7·15 kc/s for the mobile station.

(b) *Adjacent-channel interference*

With a 50 kc/s base-station transmitter on Channel 2 and 25 kc/s mobile-station receivers on Channels 1 and 3, adjacent-channel interference was just detected at distances ranging from 400 to 1,500 yards according to the depth of

modulation on Channel 2. Tests using 25 kc/s base-station transmitters on Cbannels 2 and 3 and a 50 kc/s mobile receiver on Channel 1 resulted in interference ranges of about 6 miles and 900 yards respectively.

6. Trials of 25 kc/s FM Systems

(a) *Frequency accuracy and stability*

The frequencies of all the FM, 25 kc/s-spacing, transmitters were measured daily for about five weeks and the maximum departures from tbe nominal frequencies were as follows:—

three base-station transmitters	− 0·1 to + 0·25 kc/s
tbree mobile-station transmitters	− 0·6 to + 0·5 kc/s

As before, the provisional specifications permit a variation of ± 1·5 kc/s and ± 3·0 kc/s respectively.

The remarks made in Section 4 (a) on receiver frequency stability also apply here and tbe stability bas been tested implicitly in carrying out tbe adjacent-channel-interference tests reported below.

(b) *Adjacent-channel interference*

In the absence of a wanted signal, adjacent-channel interference was just audible at about 500 yards distance and substantially similar results were obtained throughout the period. It sbould be remembered, in comparing these and subsequent 25 kc/s FM results with tbose obtained for AM, that the power of tbe FM transmitters was 20 watts, whereas the AM transmitters had a carrier power of 10 watts.

(c) *Desensitization interference* (*blocking*)

Interference from transmissions on the immediately adjacent channels due to desensitization of a mobile-station receiver on the centre channel (Channel 2) occurred up to distances of about 300 yards from tbe base station.

(d) *Cross-modulation interference*

Cross-modulation could only just be beard on tbe mobile-station receivers at a distance of 400 yards from the base station when the ratio of the unwanted signals was + 30 db at the receiver input. The signal-to-cross-modulation ratio was tbus considerably higber than tbe 20 db quoted in Section 4 (d) for the AM system at the same distance. It was also found tbat at this distance a change in tbe wanted signal of ± 10 db bad practically no effect on tbe absolute level of cross-modulation.

(e) *Intermodulation interference*

Third-order intermodulation products generated in the mobile-station receivers disabled the " squelcb " control circuits at distances up to about 1,000 yards from the base station.

(f) *Faults*

During tbe period 15th October to 19tb November, 1957, the following faults occurred: The mobile-station receivers for Channels 1 and 3 were cbanged once and twice respectively due to changes in the IF gain. A furtber mobile-station-receiver fault arose from a dry joint. A faulty crystal gave rise to intermittent trouble on the Channel 3 base-station receiver. The mobile-station transmitter for Cbannel 3 developed an intermittent fault which reduced its output.

7. Compatibility as between 25 kc/s FM and AM Systems

Trials with one or two of the three channels operated on AM and the remainder on FM indicate tbat wben different types of modulation are used within a group of contiguous channels tbe limitations are no worse tban wben tbe same type of modulation is used throughout. It will be remembered that

adjacent-channel and intermodulation interference have been shown to be slightly worse on FM than AM, while cross-modulation has been shown to be substantially better. The penalty for using different types of modulation on neighbouring channels does not extend beyond these differences.

8. Range of Service

Ignition interference was more irritating on the 25 kc/s AM system than on the 50 kc/s system, presumably because the narrower bandwidth is less favourable to limiter action. Nevertheless both systems had substantially the same range. The 25 kc/s FM-system range still compares favourably with that of both AM systems even after allowing for the higher power of the FM-transmitter. The use of 25 kc/s spacing channels should not therefore lead to any reduction of range.

9. Summary of results

The results of frequency measurements carried out during the trials are summarized in Table 2:—

TABLE 2

FREQUENCY ACCURACY OF TRANSMITTERS OVER TRIAL PERIODS

Equipment	Provisional Specification Limits (kc/s)	Maximum Departures (kc/s)
25 kc/s AM base-station transmitters ...	± 1·5	− 0·8 to + 0·6
25 kc/s FM base-station transmitters ...	± 1·5	− 0·1 to + 0·25
25 kc/s AM mobile-station transmitters	± 3·0	0 to − 0·9
25 kc/s FM mobile-station transmitters	± 3·0	− 0·6 to + 0·5

Note.—All the frequencies shown in Table 2 are relative to the nominal carrier-frequencies.

The results of the interference tests are summarized in Table 3:—

TABLE 3

SUMMARY OF RESULTS OF INTERFERENCE TESTS ON 25 KC/S SYSTEM

Type of Interference	Minimum distance of mobile station from base station for tolerable interference in mobile receiver					
	25 kc/s AM	25 kc/s FM (Note 2)	25 kc/s AM to 50 kc/s AM	25 kc/s AM to 25 kc/s FM	25 kc/s FM to 25 kc/s AM (Note 2)	50 kc/s AM to 25 kc/s AM
Adjacent channel ...	200 yds.	500 yds.	900 yds. 6 miles (Note 1)	400 yds.	450 yds.	400–1,500 yds.
Desensitization ...	100 yds.	300 yds.	—	250 yds.	300 yds.	—
Cross-modulation ...	400 yds.	(Note 3)	—	(Note 3)	300 yds.	—
Intermodulation ...	500 yds.	1,000 yds.	—	600 yds.	600 yds.	—

Note 1.—The distances of 900 yards and 6 miles relate to carrier-frequency separations of 50 and 25 kc/s respectively.

Note 2.—The FM transmitters had twice the carrier power of the AM transmitters.

Note 3.—In cross-modulation tests on FM receivers desensitization from the interfering channel masked any cross-modulation.

10. Conclusions

Although equipment from only one manufacturer has been used the following conclusions may be drawn from the trials:—

(*a*) It is possible to produce base- and mobile-station equipment which permits private mobile VHF channels covering the same or overlapping areas to be spaced at 25 kc/s intervals in the 71·5–88·0 Mc/s band.

(*b*) The tests suggest that the equipment tested could be maintained to the standards laid down in the provisional specification.

(*c*) The use of such equipment on 25 kc/s-spaced channels need not lead to a relaxation of the standards already accepted in respect of interference of various types, neither need it lead to any reduction in range. Indeed, although supporting evidence has not been incorporated in this report, the equipment tested satisfies somewhat higher interference-protection standards than are incorporated in current specifications for equipment to be used with 50 kc/s carrier spacing.

(*d*) It appears that the provisional specifications are realistic at the present stage of development.

Post Office Engineering Dept. (WP).

12.2.58.

Annex 2

Report of Sub-Committee on allocation of 25 kc/s channels in the Low Band

The Chairman,

Mobile Radio Committee.

Introduction

1. We were appointed a Sub-Committee of the Mobile Radio Committee on 14th November, 1957, with the terms of reference:

> "To formulate a new sub-allocation frequency plan for the present 'low band', consistent with the findings of the Mobile Radio Committee and assuming that 25 kc/s channelling replaces the present 50 kc/s."

The composition of the Sub-Committee is shown in Appendix 1.

2. The present plan of the low band is reproduced in Appendix 2. The plan we recommend for this band on the basis of 25-kc/s channelling is shown in Appendix 3.

Present conditions in the low band

3. The low band has been in use for about 10 years. It contains 75 per cent. of the total number of private land-mobile systems, and is favoured by users and manufacturers because the coverage obtainable with a given transmitter power and aerial height is a little better than in the "high band". There are at present 47 two-frequency channels, each 50 kc/s wide, in the low band and some of them are very crowded in and around the larger centres of population. Indeed, the Mobile Radio Committee recently recommended that, where tbe channel congestion was serious, new applicants for commercial services should be given high-band allocations only, pending the introduction of 25-kc/s channelling.

Principles of planning

4. Against tbis background we have borne three main considerations in mind in planning for the introduction of 25 kc/s channelling in the low band, namely:—

(i) the effect of the plan on the large number of existing users, who would sooner or later be faced with the cost of replacing their equipment;

(ii) the difficulties that might arise during the transition from 50-kc/s to 25-kc/s channelling; and

(iii) the equitable distribution of the additional channels that would eventually become available.

As regards (i) and (ii), we consider that the process of interleaving the new 25-kc/s channels midway between existing channels (as has already been adopted for the introduction of 50-kc/s channelling in the high band) would be the least disturbing to users, and *we recommend* its adoption. Even so, some increase of adjacent channel interference is to be expected during the change-over in the more congested parts of the band, because of the overlap between tbe old channels and tbe new. As was stated in the report submitted to the Mobile Radio Committee on the field trials of 25-kc/s channelling, such interference would affect 50-kc/s more than 25-kc/s systems, but would probably cause less inconvenience than normal channel-sharing.

5. As regards (iii), we have borne in mind throughout, first the importance of doing justice to the existing users (who, by fitting 25 kc/s equipment, would make the additional channels available) and, secondly, the need to leave a reasonable margin for unforeseen requirements arising during the lifetime of the new plan. We foresaw that the new plan, once established, would probably have to last for many years, and should therefore allow of flexibility in the allocation of channels to individual users. To this end, we considered that it would be advantageous to introduce into the plan some "general-purpose" channels, which would be available for allocation to a user of any category in an area where his requirements could not readily he met within the allocation for his particular category. Experience has shown that some categories have their own particular "problem areas", where their hasic allocation could usefully be supplemented by the allocation of general-purpose channels at the discretion of the Post Office. For example, the same general-purpose channel might he used for commercial services in London, for fuel and power services in the Midlands, and for municipal services in Lancashire. In addition to the general-purpose channels, we thought it advisable to keep a few channels in reserve to cater for requirements not foreseeable at present.

Evidence from users and manufacturers

6. The distribution of channels among the various user categories was reviewed in 1955 hy the former Sub-Committee on frequency sub-allocations, and we began our task by studying the evidence given by users and manufacturers on that occasion. We wrote to those interested in the allocation of low-band channels, asking whether they wished to amend or amplify their earlier evidence. (We did not invite fresh evidence from the television programmc contractors, whose special requirements are well known to the Post Office and are best met outside the mobile radio bands or, failing that, in the high band.) No entirely new requirements were hrought to our notice, the emphasis being on the need for more channels to allow for the development of existing types of service and improvement of their operating conditions. In particular, we noted the increased requirements of the nationalized fuel and power industries (already under consideration by the Mobile Radio Committee as a result of a report submitted by the Joint Radio Committee of those industries) and of the Automobile Association, which has plans for the improvement and expansion of its national network, at present working with 35 base stations and 450 mobile units on one low-hand channel. We noted also the view of the British Transport Commission that high-hand channels would in future be acceptable for most of the purposes for which the Railways use mobile radio.

7. None of the organizations consulted questioned the need to introduce narrower channelling in the low band at an early date. The County Councils Association, however, expressed concern at the cost to which their members were likely to be put in changing the equipment of ambulance radio systems to comply with 25 kc/s channelling, particularly as they had been enjoined hy the Government to exercise the utmost economy in expenditure.

Mobile radio systems using offset-frequency working

8. Our attention was drawn to a possible difficulty in applying 25-kc/s channelling to services using offset-frequency working within the present 50-kc/s channels. This technique is employed where two or more co-channel hase stations are needed to obtain the desired coverage with a mobile system, the carrier frequencies of the base transmitters being offset by 7 to 10 kc/s from the nominal (mid-channel) frequency to avoid causing heterodyne interference in the mobile receivers. For example, a system with three hase stations would operate with one on the nominal frequency, one 7 kc/s above it, and the other

7 kc/s below it. The mobile receivers in an offset-frequency scheme are usually tuned to the nominal frequency, and are designed with a sufficiently wide pass-band to receive the offset frequencies also. This method of working allows a large mobile system to be accommodated on a single channel and enables the mobiles to receive, without adjustment, any of the base stations; it is therefore a valuable facility to users whose mobiles often travel beyond the range of a single base-station. The services that use (or may in future need to use) offset working are mainly in the ambulance, fuel and power, and municipal and public service categories in the low band.

9. We were advised that frequency-offsetting by as much as 7 to 10 kc/s would be impracticable with 25-kc/s channelling and equipment satisfying only the minimum requirements of the provisional specification, because interference in adjacent channels would be increased to an unacceptable level. Indeed, when we began our inquiry there was some doubt whether offset working would be possible at all in 25-kc/s channels, and the question arose whether systems using offset-frequency working should be left with 50-kc/s channels in the low band or should each be provided with two or three 25-kc/s channels to replace offset by switched-channel working. We found either alternative unattractive; the latter particularly so, because it would be wasteful of frequencies and would be open to objection from users, on account of the expense of fitting mobiles with channel-switching equipment and the operational disadvantages that might arise.

10. We therefore asked the Post Office to study the technicalities of the problem further. They advised us that the use of frequency offsets of the order of 4 kc/s, combined with the necessary improvement in the tolerance of the base-transmitter frequencies, might provide an acceptable compromise at the risk of some increase in adjacent-channel interference. It was estimated that the transmitter tolerance of $\pm 1 \cdot 5$ kc/s prescribed in the provisional specification would have to be improved at least to $\pm 0 \cdot 5$ kc/s for the purpose of offset-frequency schemes. The Post Office also pointed out that there might be some initial difficulty in the design of a 25-kc/s mobile receiver with a pass-band sufficiently wide to accept the offset frequencies and at the same time meet the receiver-selectivity requirements. Nevertheless, they considered that there was every justification for assuming that offset-frequency working was practicable within 25 kc/s channels in the low band. *We therefore recommend* that the Post Office should arrange discussions with manufacturers on the necessary technical standards.

Basis of the sub-allocation plan

11. By the interleaving process already mentioned, 46 additional two-frequency channels can be produced in the low band. These additional channels have been shown with the suffix "A" in the recommended plan (Appendix 3). Our approach to the sub-allocation of the new total of 93 low-band two-frequency channels was, first, to assess the number of general-purpose and reserve channels to be provided in the interests of flexibility, and then to distribute the remainder among the existing user-categories, having regard to their prospective development. We concluded that 10 general-purpose channels and 7 reserve channels (there are already four reserve channels of 50 kc/s in the existing plan) would provide an adequate measure of flexibility. With 17 channels thus designated in the new plan, and 43 already occupied by existing services, it remained for us to distribute 33 additional channels as equitably as possible among the various classes of user, and we proceeded on the basis that each category should have its allocation increased by approximately 70 per cent. unless a special reason could be adduced to support a different figure.

12. The adjustments that followed from this process were slightly in favour of the Commercial category, whose need appears to be the most pressing. In most parts of the country, three of the additional Commercial channels (numbers 1A, 2, and 2A in the plan) could be made available immediately for new services using equipment meeting the 25 kc/s provisional specification, and might allow the present restriction (see para. 3) to be relaxed. Some of the other interleaved channels might not become available for allocation for some considerable time in the areas where they are most needed; where users already encounter difficulty through channel-sharing, it would obviously be unreasonable to make matters worse by interleaving new 25 kc/s systems capable of causing adjacent-channel interference. We have, however, placed the general-purpose channels so that some of these should become available for new services without much delay. And we have, as far as possible, allocated the new channels in such a way that the benefit of them goes primarily to the user-category that makes them available by fitting new equipment on existing channels, thus providing some incentive to adopt 25-kc/s equipment. Nevertheless, if the benefits of narrower channelling are to be realised quickly, great care will be needed in making allocations for new services, especially during the early stages of the implementation of the plan.

13. The single-frequency channels in the present plan are not allocated to user categories and *we recommend* no change in this respect, especially as it appears that some relaxation of the requirements of the 25-kc/s specification may prove necessary in respect of hand-portable equipment. The Post Office will no doubt consider this latter point in consultation with manufacturers.

Future development in the high band

14. Representatives of users on the Mobile Radio Committee have from time to time expressed the view that the adoption of 25-kc/s channelling in the low band alone would not produce sufficient channels to meet the growing requirements of users, and have urged that it should be applied in the high band also. The position of the Commercial services, mentioned above, lends weight to this view. In the case of the fuel and power industries too, the need for more high-band channels is borne out by the recommendations recently submitted jointly by the Post Office and the industries' Joint Radio Committee for an increased allocation of channels. Those proposals envisage that 11 of the recommended total of 21 channels should be in the high band, a commitment that it would be exceedingly difficult to meet without 25-kc/s channelling. We understand that field trials of 25-kc/s channelling in the high band are already in progress and show promise of reaching a satisfactory conclusion. In preparing our plan of the low band we have assumed that those user-categories whose foreseen needs are not fully met in the plan are likely to obtain some relief within the high band in due course.

Implementation of the low-band plan

15. Our terms of reference do not extend beyond the preparation of the new plan, but we have, of necessity, had to consider how the new plan might be put into effect. *We therefore suggest* the following procedure for consideration by the Committee:

(*a*) that the new plan of the low band should enter into force on the 1st June, 1959;

(*b*) that, from that date, equipment for all new services and new equipment for existing services in the low band should conform to the 25-kc/s specification;

(*c*) that, from a subsequent date—which, we suggest, should be no later than 1st June, 1964—all equipment in use in the low band should conform

to the specification prescribed for 25-kc/s equipment but, exceptionally, equipment in use at that time and not meeting the specification might continue to be used provided

(i) that it did not cause interference to other services or impede the introduction of new services, and

(ii) that the risk of interference from services on adjacent channels was accepted.

Summary of principal conclusions and recommendations

16. Our principal conclusions and recommendations may be summarized as follows:

	Para. No.
(1) The 25 kc/s channels in the low band should be introduced midway between the existing channels.	4
(2) Some general-purpose channels should be provided in the new sub-allocation plan, in the interests of flexibility.	5, 11
(3) Offset-frequency working at base stations should be permitted in 25 kc/s channels, subject to consultation between the Post Office and equipment manufacturers on the technical standards to be adopted.	10
(4) A new sub-allocation plan is recommended.	1, 11, and Appendix 3
(5) Three of the additional Commercial channels in the recommended plan could be brought into use forthwith for services using 25 kc/s equipment.	12
(6) The new plan of the low band should enter into force on 1st June, 1959, and a period of five years should be allowed for existing services to change to 25 kc/s equipment, including those services which operate on single-frequency channels.	15

F. JERVIS SMITH (*Chairman*)
H. A. DANIELS
G. F. PEIRSON
C. W. SOWTON

A. A. MEAD (*Secretary*)
3rd November, 1958.

APPENDIX 1

COMPOSITION OF THE SUB-COMMITTEE

Chairman	Mr. F. JERVIS SMITH, M.I.E.E., Deputy Secretary, Institution of Electrical Engineers.
Post Office	Mr. H. A. DANIELS, Radio Services Department.
	Mr. C. W. SOWTON, B.Sc., A.C.G.I., A.M.I.E.E., Engineering Department.
Nationalized Fuel and Power Industries.	Mr. G. F. PEIRSON, M.I.E.E., M.Amer.I.E.E., Deputy Chairman, Midlands Electricity Board.
Secretary	Mr. A. A. MEAD, Post Office (Radio Services Department).

APPENDIX 2

PRESENT PLAN OF THE LOW BAND

Mobile Freq.	Channel No.	Category of User	Base Freq.
Mc/s 71·5	1	Reserved	85·0 Mc/s
	2		
	3	Public Transport and Municipal and Public Services	
	4		
	5		
	6	Fuel and Power	
	7	Public Transport and Municipal and Public Services	
	8		
	9		
	10	Industrial	
72·0	11	M. & P.S.	85·5
	12	Fuel and Power	
	13	Commercial	
	14		
	15		
	16		
	17		
	18	Commerical and Industrial	
	19		
	20		
72·5	21	Ambulance and Medical	86·0
	22		
	23		
	24	Industrial	
	25	Fuel and Power	
	26		
72·8			86·3

Mobile Freq.	Channel No.	Category of User	Base Freq.
Mc/s 76·95	27	Ambulance and Medical	86·95 Mc/s
77·0	28	Commercial	87·0
	29		
	30	Public Transport	
	31		
	32		
	33		
	34	Ambulance and Medical	
	35		
	36		
	37	Industrial	
77·5	38	Ambulance and Medical	87·5
	39		
	40		
	41		
	42	Industrial	
	43	Reserved	
	44		
	45	Press	
	46		
	47		
78·0			88·0
86·3	S1	Single Frequency Services	
	S2		
	S3		
	S4		
	S5		
	S6		
	S7		
	S8		
86·7			

Note: One or more frequencies in the Ambulance and Medical Category not required for ambulances in London may be re-allocated for the Commercial Category in London.

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APPENDIX 3

RECOMMENDED 25 KC/S CHANNELLING PLAN OF THE LOW BAND

Mc/s			Mc/s	Mc/s			Mc/s
71·5	1 Reserved	1A Commercial	85·05	76·95	27 A. & M.	27A General Purpose	87·0
71·55	2 Commercial	2A Commercial	B.F.	77·0	28 M. & P.S.	28A General Purpose	B.F.
M.F.	3 M. & P.S.	3A P.T. & M. & P.S.		M.F.	29 Commercial	29A General Purpose	
	4 M. & P.S.	4A M. & P.S.			30 P.T.	30A P.T.	
	5 P.T. & M. & P.S.	5A F. & P.			31 P.T.	31A P.T.	
	6 F. & P.	6A M. & P.S.			32 P.T.	32A General Purpose	
	7 P.T. & M. & P.S.	7A M. & P.S.			33 P.T.	33A General Purpose	
	8 P.T. & M. & P.S.	8A General Purpose			34 A. & M.	34A A. & M.	
	9 P.T. & M. & P.S.	9A General Purpose			35 A. & M.	35A A. & M.	
	10 Industrial	10A M. & P.S.			36 A. & M.	36A Reserved	
	11 M. & P.S.	11A M. & P.S.			37 Industrial	37A Reserved	
	12 F. & P.	12A General Purpose			38 A. & M.	38A A. & M.	
	13 Commercial	13A Commercial			39 A. & M.	39A A. & M.	
	14 Commercial	14A Commercial			40 A. & M.	40A A. & M.	
	15 Commercial	15A Commercial			41 A. & M.	41A Industrial	
	16 Commercial	16A Commercial			42 Industrial	42A Industrial	
	17 Commercial	17A Commercial			43 Reserved	43A Reserved	
	18 C. & I.	18A C. & I.			44 Reserved	44A Reserved	
	19 C. & I.	19A C. & I.			45 Press	45A Press	
	20 C. & I.	20A Commercial		77·95	46 Press	46A Press	87·95
	21 A. & M.	21A A. & M.			47 Press		
	22 A. & M.	22A A. & M.		78·0			
	23 A. & M.	23A General Purpose					
	24 General Purpose*	24A F. & P.					
	25 F. & P.	25A F. & P.					
72·75			86·25				
72·8	26 F. & P.						

SINGLE FREQUENCY SERVICES

86·3	S1
	S1A
	S2
	S2A
	S3
	S3A
	S4
	S4A
	S5
	S5A
	S6
	S6A
	S7
	S7A
86·7	S8

M.F. ... ... Mobile Frequency
B.F. ... ... Base Frequency
P.T. ... ... Public Transport
M. & P.S. ... Municipal & Public Services
F. & P. ... Fuel and Power
C. & I. ... Commercial & Industrial
A. & M. ... Ambulance & Medical

* Channel 24 is at present used by services of the Central Electricity Generating Board which are to be moved to a single-frequency channel.

Annex 3

Composition of the Mobile Radio Committee

Mr. W. A. Wolverson, C.B., Post Office (Chairman)

Mr. J. R. Brinkley, Pye Telecommunications Ltd.

Mr. J. W. Clater, B.Sc.(Eng.), A.M.I.E.E., Marconi's Wireless Telegraph Co. Ltd.

Mr. H. A. Daniels, Post Office

Mr. H. D. Edwards, Municipal Ambulance Service, Cardiff

Mr. G. W. Harvey, Ministry of Transport and Civil Aviation

Mr. I. T. Lawman, Ministry of Transport and Civil Aviation

Capt. L. P. S. Orr, M.P., Mobile Radio Users' Association

Mr. G. F. Peirson, M.I.E.E., M.Amer.I.E.E., Midlands Electricity Board

Mr. F. Jervis Smith, M.I.E.E., Institution of Electrical Engineers

Dr. R. L. Smith-Rose, C.B.E., D.Sc., M.I.E.E., Department of Scientific and Industrial Research

Mr. C. W. Sowton, B.Sc., A.C.G.I., A.M.I.E.E., Post Office

*Mr. H. S. Vian-Smith, M.C., Summerson Holdings Ltd.

Capt. F. J. Wylie, R.N. (Retd.), Radio Advisory Service to the Chamber of Shipping and Liverpool Steam Ship Owners' Association

Mr. G. McIvor, Mobile Radio Users' Association } Joint Secretaries
Mr. A. A. Mead, Post Office }

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* Mr. Vian-Smith was unable to attend the meetings at which this Report was prepared.

(87700) Wt. 4338—31/01245 K13 3/59 D.L.

Printed and published by
HER MAJESTY'S STATIONERY OFFICE

To he purchased from
York House, Kingsway, London w.c.2
423 Oxford Street, London w.1
13A Castle Street, Edinhurgh 2
109 St. Mary Street, Cardiff
39 King Street, Manchester 2
Tower Lane, Bristol 1
2 Edmund Street, Birmingham 3
80 Chichester Street, Belfast
or through any hookseller

Printed in Great Britain

S.O. Code No. 43–171–0–59